Understanding the Vegetation and Hydrology of Upper Midwest Wetlands

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Presentation Summaries and References

Water Balance in Northern Peatlands and Impacts of Peat Mining on Surface Waters

Kenneth N. Brooks, University of Minnesota, Department of Forest Resources, St. Paul, MN

Peatlands in northern Minnesota occur where there is an excess of water at the earth's surface and where the physiography is conducive to slow water movement. The water balance of northern peatlands is influenced by the extent to which they are connected to regional groundwater. Precipitation maintains the water table and thus governs the water balance of perched or raised peatlands, referred to as bogs, which have little connectivity to regional groundwater. Peatlands that are more directly connected to regional groundwater are called fens; their water balance is governed by both regional groundwater and precipitation. Water budgets for small bogs and fens in the Marcell Experimental Forest are contrasted with those of larger peatlands that are found in northern Minnesota. In all types of peatlands, annual evapotranspiration is a dominant component of the water balance which far exceeds discharge to surface waters. When a peatland is drained and peat is extracted (mined), hydraulic gradients and pathways of water flow are altered in ways that produce greater discharge to surface water. In contrast to natural peatlands, surface runoff from mined peat fields can increase because of a more continuous concrete type soil frost in the springtime and hydrophobic conditions of peat surfaces during dry summers. Surface water responses of mined and unmined peatlands are contrasted in this presentation.

The Importance of Groundwater-Surface-Water Exchange and How it can be Quantified

Don Rosenberry, U.S. Geological Survey, Denver, CO

When the USGS Circular "Ground water and surface water – a single resource" was released in 1998 it was a revolutionary concept to many water-resource managers who previously had considered groundwater and surface water as separate entities. Since then, the demand for better understanding of the linkages between various expressions of this single resource has led to innovative new techniques for quantifying this exchange. Selecting the appropriate method often depends on the scale of the resource being studied. Examples of water-resource problems that required quantification of exchange between groundwater and surface water, followed by the appropriate method for examining the problem, will be presented. The talk will conclude with a listing of methods for quantifying groundwater-surface-water exchange and a link to the recently released USGS report that provides additional details.

The Hydrology and Biogeochemistry of Bog Watersheds in Northern Minnesota; Findings from Long-Term Studies and Experiments at the Marcell Experimental Forest

Stephen Sebestyen, USDA Forest Service, Northern Research Station, Grand Rapids, MN

Long-term data from experimental watershed studies are invaluable records of ecosystem dynamics. The Marcell Experimental Forest (MEF) was established in the 1960s to fill a geographic and ecological void in the USDA Forest Service Experimental Forest and Range network -- no other site in the Forest Service network and few other sites around the globe have monitoring schemes and large scale experiments that were designed to advance our understanding of the hydrology, biogeochemistry, and ecology of watersheds having uplands that drain through peatlands to streams. Now, after nearly five decades, the long-term data from watershed monitoring and experiments document the baseline ecology and hydrology of these watersheds as well as responses to forest management, the deposition of pollutants from the atmosphere, and climate variability. I will present key research findings from the Marcell Experimental Forest research site to give examples of how long-term research programs can be used to better understand important peatlands functions and how peatland landscapes respond to natural disturbance and human activities that alter the environment.

Hydrology of Wisconsin Wetlands and the Value of Heat and Isotopes

Michael N. Fienen, U.S. Geological Survey, Madison, WI

Natural tracers have great potential for understanding the interactions between groundwater and wetland systems. Residence time and environmental signatures of natural tracers can provide information about flowpaths and provenance, insight valuable to modeling groundwater flow and tracer transport through the hydrologic cycle. Different natural tracers provide distinct information about processes. In this work, we focus on $\delta^{18}O$ and temperature in a wetland-stream complex at the Trout Lake Water, Energy and Biogeochmical Budgets/ North Temperate Lakes Long Term Ecological Research site in northern Wisconsin, USA. Modeling $\delta^{18}O$ provides information on provenance of water flowing through the wetland into the stream due to fractionation signatures that differentiate recharge through a nearby lake, wetland or terrestrial sediments. Modeling temperature profiles near the wetland surface and temperature anomalies measured in the stream characterizes the distribution of water exchange occurring between preferential flowpath conduits in soil pipes and slower flowpaths traveling through the peat matrix.

A coupled model of groundwater flow (using MODFLOW-2005) and $\delta^{18}O$ and heat transport (using MT3DMS) is constructed with 24 layers in a highly-parameterized context using pilot points to represent spatially variable hydrogeologic and thermal properties. The highly-parameterized approach allows for flexibility facilitating identification of potential heterogeneity and reduction of the structural component of epistemic uncertainty. The coupled model was calibrated to conditions in 2005 and 2006 using PEST. Through the parameter estimation process, the identifiability of specific parameters was examined using singular value decomposition and associated statistics. The leverage and influence of the three data types (hydraulic data, heat and $\delta^{18}O$), before and after calibration, are quantified and examined to indicate the relative value of the distinct tracer types for the processes being simulated by the model.

The outcome of this work is a systematic approach to evaluating the impact of natural tracers on accurately modeling groundwater and surface water interaction in a wetland-stream environment. Important considerations of linking the flow and transport models are discussed. While $\delta^{18}O$ provides integrative flowpath delineation on the large scale, temperature informs the local interactions near the surface and their combination in a holistic approach results in a model capable of addressing the response of the wetland-stream environment to multiple scales of changing conditions including land use and climate change.

Wild Rice and Water - an Interwoven Web

Peter David, Great Lake Indian Fish and Wildlife Commission, Odanah, WI

Although affected by many ecological factors, long-term manoomin abundance on suitable habitat is often driven by hydrologic conditions, and its loss from many localities is related to disturbances of natural hydrologic regimes. Within a single growing season, rice generally prefers relatively stable or gradually receding water levels, but as an annual plant, rice also benefits from a degree of ecological disturbance between years. Presently, water levels on many rice beds are manipulated for commercial, economic or recreational purposes with little consideration of the impacts to the rice resource. The historic hydrology of many manoomin waters is also being impacted by local and landscape level changes in the landscape and climate.

This presentation will review some of the impacts that hydrological alterations can have on rice, both positive and negative - and how a similar disturbance can have very different impact on particular rice waters. It will discuss what are reasonable expectations for long-term crop abundance, and explore options that managers may have to attempt to maintain that abundance. Finally it will touch upon the need to gain greater public acceptance of natural hydrological variation - without reducing concern regarding hydrological variation induced by climate change.

Building Community Awareness and Support for Wetlands through Recognition: Wetland Gems and Ramsar

Katie Beilfuss, Wisconsin Wetlands Association, Madison, WI

Public consciousness still holds a negative stereotype of wetlands. Wetlands are “wastelands.” They breed mosquitoes and other pests. They stand in the way of development. Even our lexicon reflects this perception: what other valuable natural resource suffers from an ocean of such dubious expressions as “swamped,” “mired,” and “bogged down”? The work of the Wisconsin Wetlands Association – and that of anyone working for wetland conservation – will be hampered until we inspire a casting change for wetlands from “obstacles” to “treasures.”

Recently, Wisconsin Wetlands Association developed and implemented two programs strategically designed to raise the public’s awareness of and interest in important wetland resources. In 2009, we announced our *Wetland Gems* program, which highlights the wetland riches—marshes, swamps, bogs, fens, and more—that historically made up nearly a quarter of Wisconsin's landscape. Critical to Wisconsin's biodiversity, these natural treasures also provide our communities with valuable functions and services as well as recreational and educational opportunities. In that same year, we launched a strategic process to identify and nominate some of these same wetlands for recognition as Wetlands of International Importance through the international Ramsar Convention on Wetlands. Both initiatives are designed to raise public awareness of the value and importance of wetlands and increase protection for these critical resources.

This presentation will discuss why Wisconsin Wetlands Association developed these initiatives, how the *Wetland Gems* and Ramsar candidate sites were selected, and the work we are doing to continue to protect and promote these natural treasures.

Wetland Plant Communities of the Upper Midwest

Steve D. Eggers, U.S. Army Corps of Engineers, St. Paul, MN

There are numerous methods for describing or classifying wetland plant communities of the Upper Midwest. These vary from the relatively simple (8 wetland types using Circular 39 by Shaw and Fredine (1971)) to more comprehensive (15 wetland plant communities of Eggers and Reed (1987)) to most comprehensive (41 native wetland plant community classes in the Minnesota DNR's *Field Guides to the Native Plant Communities of Minnesota* (2003, 2005)). There are also specialized classification systems for specific wetland systems such as *The Canadian Wetland Classification System* (1997), which could be applicable to northern peatlands of the Upper Midwest. Others were developed for a specific purpose, e.g., the U.S. Fish and Wildlife Service adopted Cowardin *et al.* (1979) for mapping wetlands as part of the National Wetland Inventory.

All of the above have their uses. Circular 39 is written into Minnesota statutes. Eggers and Reed is being used for regulatory purposes in evaluating projects that would impact wetlands. The Minnesota DNR's native plant community guides are being used for inventorying natural areas and identifying natural heritage sites. When preparing a report describing wetland plant communities of a site/watershed/county/ceded area, a good idea is to include a table that crosswalks between the various wetland classification systems.

For my presentation, I'm going to describe the vegetation and associated hydrology of the 15 wetland plant communities in Eggers and Reed (1987). These include forested wetland communities (floodplain forests, hardwood swamps, coniferous swamps and coniferous bogs), shrub communities (shrub-carrs, alder thickets and some open bogs), and herbaceous communities (shallow/open water, deep marshes, shallow marshes, sedge meadows, fresh (wet) meadows, wet/wet-mesic prairies, calcareous fens, seasonally flooded basins and some open bogs).

Groundwater-Peatland-Carbon Coupling in Northwestern Minnesota and its Response to Climate Change

Paul Glaser, University of Minnesota, Limnological Research Center, Minneapolis, MN

Northern peatlands are a key component of the Global Carbon Cycle because of their role as both an important source and sink for greenhouse gases. Peatlands cover more than 56% of the regional landscape in northwestern Minnesota forming the largest expanse of raised bogs, patterned water tracks, and bog complexes within the contiguous United States. Field research over the past 30 years has shown that the formation of these peatland patterns is closely coupled to groundwater flow systems. On the one hand regional flow systems transport of inorganic solutes from the underlying calcareous deposits to the peat surface determining the distribution of the principal peatland types. However, on the other hand the accumulation of peat into 3-dimensional peat landforms alters the topography of the water table creating complex interactions between local and regional flow systems. A further layer of complexity is produced by the production of methane bubbles within the deeper peat strata by the anaerobic breakdown of dead organic matter. Large overpressured pockets of methane bubbles tend to form under hydraulic confining layers that episodically rupture to release large volumes of this greenhouse gas to the atmosphere. A large integrated array of instrument stations (Red Lake Peatland Observatory) has now been installed in the 1300 km^2 Red Lake Peatland to investigate these interactions among carbon, water, and climate in more detail at multiple scales.

Floristic Quality Assessment for Minnesota Wetlands

Michael Bourdaghs, Minnesota Pollution Control Agency (MPCA), St. Paul, MN

Floristic Quality Assessment (FQA) is an ecological condition assessment approach that has been gaining popularity for over 30 years. At FQA's core is the Coefficient of Conservatism (*C*) which is a numerical rating of each plant species from 0 - 10 that expresses the species' fidelity to natural habitats and tolerance to disturbance (both natural and anthropogenic). Metrics derived from the *C*-values, such as the Mean *C* and/or Floristic Quality Index (*FQI*), for plant species occurring at a given site are then used assess site condition. In 2007, the MPCA completed a project to assign *C*-values to Minnesota's wetland flora. Since that time, work has continued to further develop FQA into a standardized wetland condition assessment tool. Two major objectives are currently being pursued: 1) development of a standard rapid sampling protocol that relies on a timed meander approach and a simplified plant species list; and 2) development of data driven assessment criteria. This 'Rapid FQA' will allow wetland professionals with moderate levels of botanical expertise to make defensible wetland condition assessments with a reasonable amount of effort. It is anticipated that the Rapid FQA will have applications in wetland regulatory, effectiveness, and ambient status and trends monitoring.

Vegetation Condition and Water Quality in Great Lakes Coastal Wetlands

Carol Johnston, University of South Dakota State, Department of Biology and Microbiology, Brookings, SD

Great Lakes coastal wetlands are distributed along both natural and anthropogenic gradients that affect the plant species present. Vegetation traits can be useful indicators of wetland condition if they respond to human activities that degrade wetlands. The proportion of invasive plant species is an important indicator of wetland condition, and aggressive taxa such as non-native *Phragmites* are rapidly expanding within Great Lakes coastal wetlands. Two composite indices of plant assemblages, the Floristic Quality Index and a statistically-derived index, are useful for evaluating wetland condition across a variety of vegetation types, and can help identify anthropogenic stressors that degrade condition. Water chemistry varies across the northern Great Lakes and their wetland plant communities. Among 30 wetlands sampled in the northern Great Lakes, wetlands in Lake Superior had the lowest pH, specific conductance, and chloride concentrations, whereas cattail marshes in northern Lake Michigan had the highest nutrient concentrations, chlorophyll a, and total suspended solids. Water chemistry was less related to wetland hydrogeomorphology than expected. An understanding of wetland water chemistry is an important first step toward setting water quality standards for wetlands.

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Johnston, C.A., D. Ghioca, M. Tulbure, B. Bedford, M. Bourdaghs, C. B. Frieswyk, L. Vaccaro, and J. B. Zedler. 2008. Partitioning vegetation response to anthropogenic stress to develop multi-taxa wetland indicators. Ecological Applications 18:983-1001.

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Tulbure, M.G., and C.A. Johnston. 2010. Environmental conditions promoting non-native *Phragmites australis* expansion in Great Lakes coastal wetlands. Wetlands 30:577-587.

Assessing Wetland Anthropogenic Stress Using GIS; A Multi-Scale Watershed Approach

Thomas P. Hollenhorst, U.S. Environmental Protection Agency, Duluth, MN

Watersheds are widely recognized as essential summary units for ecosystem research and management, particularly in aquatic systems. As the drainage basin in which surface water drains toward a lake, stream, river or wetland at a lower elevation; watersheds represent spatially explicit areas within which terrestrial stressors can be quantified and linked to measures of aquatic ecosystem condition. Traditionally watersheds were delineated manually using maps of streams, lakes, and elevation contours, but more recently watersheds are digitally delineated within a geographic system using digital elevation data. Using flow direction and flow accumulation grids derived from elevation maps, stream networks are identified based on a minimum flow accumulation threshold. This allows for selectively delineating streams at either broad scales or very fine scales, depending on the size of the flow accumulation threshold. Once the stream networks are delineated, flow direction is used to delineate the contributing area or

sub-catchment for each stream reach between stream confluences. Each sub-catchment is given a unique "hydro-id" and the next down hydro-id is identified for the next catchment a particular catchment flows into. These attributes are also transferred to the corresponding stream reach and pour points. Because the data contains the "nextdown" id, it is possible, to accumulate information (i.e. number of pt. sources etc.) about each catchment as the streams are followed down the drainage network. This also allows us to trace the drainage network either upstream from a particular point or downstream from that point providing custom watershed delineations for locations of interest. Examples of various watershed delineation tools, sources for data and example applications will be presented.

The Importance of Wetlands in the Linked Biogeochemical Cycles of Mercury, Sulfur, and Carbon

Mark E. Brigham, U.S. Geological Survey, Mounds View, MN

Emission of mercury to the atmosphere results in its global dispersion. As a result, aquatic ecosystems worldwide—including those that lack direct industrial, mining, or geologic point sources—have mercury levels elevated above background. Within aquatic ecosystems, decomposition of natural organic matter by iron-reducing and particularly sulfate-reducing bacteria converts some portion of inorganic mercury to methylmercury, a highly toxic, bioaccumulative form of mercury. This process readily occurs in wetlands, which are rich in natural organic matter and provide a dynamic biogeochemical environment for mercury, sulfur, and organic carbon cycling. Wetlands provide important ecosystem benefits, but are also important zones of methylmercury production. At the landscape scale, wetland abundance within watersheds is strongly linked to methylmercury concentrations in water and biota of streams or lakes. Methylmercury production in wetlands and other aquatic environments is sensitive to mercury inputs, sulfate inputs, and physical disturbances.

<u>Mercury References</u>

Fish consumption advice:

Minnesota Fish Consumption Advice: http://www.health.state.mn.us/divs/eh/fish/
Wisconsin Fish Consumption Advice: http://dnr.wi.gov/fish/consumption/
Blue Ocean seafood guide: www.blueocean.org/seafood
U.S. EPA, National Listing of Fish Advisories, Technical Fact Sheet: 2008 Biennial National Listing. http://www.epa.gov/waterscience/fish/advisories/tech2008.html

Research papers:

<u>Increased mercury deposition:</u> (*1-5*)
<u>Natural mercury deposits:</u> (*6*)
<u>Toxicity of methylmercury to humans</u> (*7-9*) <u>and wildlife</u> (*10-11*).
<u>Health benefits of fish consumption, versus methylmercury risk</u>: (*12*)
<u>Organic matter bacterial decomposition processes:</u> (*13*)
<u>Mercury methylation by bacteria</u>: (*14-16*)
<u>Importance of wetlands as sources of methylmercury:</u> (*5, 17-20*)

Methylmercury increases in relation to mercury inputs (*21*), sulfate inputs (*22*), and physical / hydrologic disturbances (*23*-*26*).
Importance of sulfur (*15, 27*) and organic matter (organic carbon) (*5*, *17*, *28*-*29*) in mercury cycling.
Methylmercury in Minnesota rivers: (*30*-*33*)
Hydrologic landscapes: (*34*)

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Use of Chironomides (Aquatic Insects) as an Indicator of Water Quality in Wetlands

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Chironomidae are a family of aquatic flies (Diptera) that have a wide range of tolerances to habitat alterations and differing classes of pollutants. In high-quality aquatic systems with excellent-to-good water quality they can be highly species-rich, with one hundred or more species present. However, because of their small sizes, abundances and difficulty associated with species-level identification, they are often ignored in bioassessment programs. In this presentation, I will describe and discuss a rapid-bioassessment field collection protocol that we have developed in order to more effectively integrate collections of Chironomidae into water quality assessments. The method we have refined uses collections of the shed pupal “skins” that are left behind on the surface of the water after adults emerge. We have also developed identification guides and protocols for analyzing data that are appropriate for these types of collections. I will also discuss the type, quantity of historical data available in our research files and summarize the habitats for which historical data are available.

Wild Rice Population Cycles in Relation to Nutrient Availability and Decay of Rice Litter

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Wild rice populations cycle, with years of high productivity often followed by a crash the next year and a slow recovery lasting 3 or 4 years. We think wild rice induces these population cycles because of a delay in the release of nitrogen from its litter. Nitrogen is the nutrient most limiting to growth. Being and annual plant, wild rice must take up all the nitrogen it needs each year. More than half of the uptake happens in a brief two week window in later spring or early summer. But the nitrogen in the previous year's straw litter is not yet being released by microbes – in fact, the microbes are outcompeting the plants for nitrogen from water and sediments. The nitrogen begins to be released only later in the summer of the first year of decay and most of it is released during the second year of decay. This delayed release of nitrogen causes the crash but also allows for the recovery of the plant production. We have been doing experiments over the past 6 years to understand this process. I will present results of these experiments, including data on how uptake by plants and microbes changes the chemistry of the water over the growing season.

Using Core Samples from Lakes to Understand Past Ecological Changes and the Impacts of Land Use: Manoomin Project

Amy Myrbo, University of Minnesota, Limnological Research Center, Minneapolis, MN

Management and conservation of wetlands and other natural areas is enhanced when stakeholders have access to a long-term record of ecological changes. Instrumental and monitoring data provide only years to decades of information; sediment core samples from the bottoms of lakes can record thousands of years of variability on the landscape and in water bodies, albeit at lower resolution. Changes in aquatic and terrestrial plant communities, nutrient status and water chemistry, drought, erosion, and lake depth, among other characteristics, can be "reconstructed" from components of lake and wetland cores. Fond du Lac Resource Management Division, along with Fond du Lac Tribal and Community College and the University of Minnesota, are conducting a five-year research, training, and education project, *manoomin* (wild rice, *Zizania palustris*), that involves Native students and their teachers in research using core samples from Reservation wild rice lakes. Students collect cores during the winter as part of the long-running *gidakiimanaaniwigamig* (Our Earth Lodge) weekend science camps for all ages. Science mentors from the U of M and other institutions work closely with students during core collection, initial core logging and analysis, and during 1-week research internships at the Minneapolis and Duluth campuses; at the end of the internships, students collaboratively integrate results from the study of different ecological indicators found in the cores. The project takes advantage of the open laboratory of LacCore, the National Lacustrine Core Facility, in Minneapolis. LacCore is supported by the National Science Foundation and the U of M with the mandate of providing low-cost support for core-based research on lakes, rivers, and wetlands, and assisting any researcher who wishes to use cores to better understand the ecological history of any region. This presentation will provide information and recommendations on desirable project targets, costs involved in core collection, dating, and analysis, and involving students and communities in core-based projects.

Mapping and Monitoring Minnesota's Marshes from Above

Steve Kloiber, Minnesota Department of Natural Resources, St. Paul, MN

In 2006, several agencies from the state of Minnesota along with federal agencies collaboratively developed a comprehensive wetland assessment, monitoring, and mapping strategy for Minnesota. This strategy document makes several recommendations for a scientifically sound approach for monitoring and assessing wetland quantity and quality statewide. This presentation will cover two components of the overall strategy: updating the national wetland inventory and implementing a wetland status and trends monitoring for the state.

The update of the original National Wetland Inventory maps, which date from the early 1980's, will make these data more accurate and will include additional wetland attribute information. This project, which began in 2008, will ultimately produce updated, digital wetland maps for the entire state. The maps will be based on a variety of data, including high-resolution, spring, leaf-off, aerial imagery, summer imagery and LiDAR data. Initial testing of wetland identification using LiDAR data show considerable promise, with classification accuracies around 90%.

In 2006, Minnesota implemented a random sample wetland monitoring program. This monitoring program involves repeatedly mapping wetlands in 4,990 randomly selected 1-square mile plots over a three year cycle. The data from this survey are intended to answer questions regarding the status and trends of wetland quantity and quality in Minnesota. The wetland quantity data from 2006-2008 indicate that wetlands comprise 19.6% of the sampled area. Based on this information, the estimated total wetland area for Minnesota is 10,600,000 acres.

A Systematic Approach for the Characterization of the Water Needs for Discharge Groundwater-Dependent Ecosystems

Christopher Carlson, USDA Forest Service, Washington D.C.

In many parts of the US, the Forest Service is facing increasing requests to access water off of National Forest System lands for human uses, such as irrigation and public water supply, or withdraw water for mining, energy, or other development. Inevitably, these requests put the Forest Service in the position of having to evaluate whether groundwater can be removed from a particular hydrologic system while maintaining the viability of the dependent ecosystems, and how much can be removed over what periods of time. The "Framework for the Determination of Environmental Water Requirements for Ground Water Dependent Ecosystems" addresses water requirements for springs, groundwater discharge wetlands, and areas of terrestrial vegetation that are supported by a shallow water table (phreatophytes). Strongly groundwater dependent systems occupy only a small percentage (1% or 2%) of the land area. However, they are highly significant from a conservation perspective because in many landscapes biodiversity is focused on these areas of stable, generally high-quality water.

Environmental Water Requirements (EWRs) define the water regime necessary to protect biologically relevant goals, criteria, and indicators that prevent significant harm to groundwater-dependent aquatic and wetland habitats while at the same time considering human livelihoods and well-being. Much research has gone toward deriving EWRs for rivers. Few studies, however, have addressed water requirements for GDEs. Key questions include:

• Which populations or species of an ecosystem are groundwater-dependent?
• If some populations or species of an ecosystem are groundwater-dependent, what is the degree of dependency?
• What is the nature of the aquifer(s) supplying water to the system?
• What attributes of groundwater (level, flux, quality) are important to sustain the system?
• What are the safe limits to changes in the attributes of groundwater?

The Framework has a step-wise approach that includes:
1) a threat analysis and definition of management objectives,
2) understanding the biophysical setting and the form and degree of dependence on groundwater,
3) developing an environmental response function, and
4) setting an EWR with monitoring and evaluation criteria.

The Forest Service is currently working with The Nature Conservancy to apply the Framework to several fens in Oregon within an existing grazing allotment that have been developed to supply stockwater in order to identify limits on the timing and amounts of water that be withdrawn.

Determining Indirect Impacts to Wetland Plant Communities Resulting from Mine-induced Changes to Groundwater Hydrology: The Crandon Mine Experience

James L. Arndt, Westwood Professional Services, Minneapolis, MN

The purpose of NEPA is to promote informed federal agency decision-making by ensuring that detailed information concerning significant environmental impacts associated with projects involving federal activities (e.g. permits, grants, etc.) is available to both agency leaders and the public. An environmental Impact Statement (EIS) is the most detailed NEPA instrument that is reserved for projects that have a substantial potential for adverse environmental impact. It is incumbent upon the lead and reviewing agencies to identify and evaluate the likelihood and magnitude of significant impacts. If potential impacts cannot be identified or their magnitude determined, informed decisions regarding the nature of the impacts, and the potential for avoidance, minimization, and mitigation cannot be made.

The Crandon Mine Project was proposed to extract and process zinc/copper/lead ores from a large, underground reserve in Forest County Wisconsin approximately five miles south of the City of Crandon. The proposed Project was subject to an EIS with the St. Paul District of the US Army Corps of Engineers as the lead agency. The mine included typical infrastructure associated with deep shaft mining of non-ferrous reduced ore metals, including but not limited to surface support facilities, access roads, a railroad spur line, electrical power transmission line, a natural gas pipeline, a tailing management area, and a soil absorption system (SAS) to discharge soft treated tailings wastewater into the swamp creek watershed.

Direct impacts to aquatic resources (e.g. fills, excavations, and diversions) were relatively easy to identify by comparing pre-construction and post-construction surveys. However, EIS scoping identified a potential indirect adverse impact to the natural function of aquatic resources resulting from (1) long-term reductions and rises in groundwater levels associated with mine dewatering during operations and closure, respectively, and (2) long-term rises and reductions in groundwater levels associated with the operation and subsequent closure, respectively, of the soil absorption system proposed to naturally deliver treated water to the Swamp Creek watershed. This presentation summarizes the methodology employed to evaluate these indirect effects, including:

- *Evaluate existing information* on aquatic resources, functional assessments, and determination of recharge, flowthrough, and discharge hydrology.
- *Gather, analyze, and prepare additional information* and develop plant community classifications that can be used to evaluate specific ecosystem response to fast and gradual changes in groundwater hydrology. This involved gathering detailed soil and plant distribution associated with specific hydrogeologic settings, analyzing same, and reclassifying the Crandon wetland plant communities into Native Plant Community (NPC) Classes, Types, and Subtypes that classify plants based on hydrologic, ecologic, and edaphic processes.
- Using field-verified signatures and air photo interpretation, *reclassify Crandon wetlands* into various NPC types and stratify by recharge, flowthrough, and discharge hydrologic settings.
- *Develop Hydrologic Impact Sensitivity Groups* (HSIGs) for each NPC wetland type based on best professional judgment of the natural progression of plant community distribution change from one adapted natural community to another adapted natural community in response to groundwater impacts. Relate HSIGs of none-to-slight, moderate, and severe to speed AND magnitude of hydrologic change.
- *Identify and visualize plant community changes* on ordination figures based on an extensive existing datasets for the same plant communities in Minnesota.
- *Evaluate the various groundwater drawdown models* that predicted maximum groundwater drawdown and mounding contours associated with plant dewatering and SAS water applications.
- *Identify specific high-risk wetlands* that, because of their inferred hydrology, predicted drawdown magnitude, and plant community composition, would be particularly sensitive to mine-induced drawdown.

This effort fulfilled the requirements of NEPA for the Crandon EIS by (1) characterizing the important components of the affected environments, (2) identifying particularly sensitive aquatic-resource components, and (3) predicting the range of potential effects of mine-induced groundwater manipulation on sensitive aquatic resources. The analysis informed agencies about potentially significant impacts to wetland functions resulting from mine induced changes to groundwater levels. Once the potential range in impacts was identified, decisions regarding avoidance, minimization and mitigation could be realistically discussed. Actual impact mitigation was planned be based on monitoring of sensitive and representative wetlands throughout the operations and closure phases.

References to assist the workshop attendees

Minnesota Department of Natural Resources. 2003. Field guide to the native plant communities of Minnesota: The laurentian mixed forest province. Ecological Land Classification

Program, Minnesota County Biological Survey, and Natural Heritage and Noongame Research Program, MDNR St. Paul.
Explains in detail the NPC and it's important components as used in Minnesota.

Shaw, D. and R. Schmidt. 2003. Plants for stormwater design. Minnesota Pollution Control Agency.
Discusses the hydrologic regime of specific plants and the concept of saturation and flooding tolerances in adapted plants.

The Use of Constructed Wetlands in Mine Reclamation

A Paul Eger, Minnesota Department of Natural Resources, St. Paul, MN

Wetlands have been used to successfully treat mine drainage for about 20 years. When properly sized and maintained, they offer lower cost, lower maintenance alternatives to standard chemical treatment plants. The type and size of the treatment wetland is a function of the input flow and water quality, the treatment efficiency of the wetland and the water quality limits.

Five surface flow wetland treatment systems were built in the 1990's at the Dunka mine to remove copper, nickel, cobalt and zinc from stockpile seepage. System design, maintenance and performance of the wetland systems varied. Some systems have required essentially no maintenance and have produced water that has always been in compliance, while others have required a variance to maintain compliance and have required a considerable amount of reconstruction.

The key factors in performance were the size of the wetland and flow distribution. An areal nickel removal rate of about 40 mg/m^2 day was determined in pilot cell tests prior to wetland construction. In general, the systems that met this requirement produced the most consistent compliance with water quality standards.

For one of the wetlands, treatment lifetime was estimated based on a model of substrate accumulation in wetlands. Based on this model, the projected lifetime is on the order of several hundred years.

Remote Sensing Techniques for Improved Wetland Mapping

Brian Huberty, U.S. Fish and Wildlife Service, Fort Snelling, MN

Wetlands are the most dynamic landscape feature to map and monitor, thereby highlighting the need for new and current information about the scope, condition and extent of wetlands on a more frequent cycle. New technologies such as digital aerial cameras, Radar, Lidar and Thermal Cameras have now made it possible to accurately map wetlands at frequent intervals. This talk will highlight many of the new approaches being used in Minnesota and around the region to help improve our wetland mapping systems.

WETLAND MAPPING WEBSITES

As of March 1, 2010

MINNESOTA

Department of Natural Resources – Wetland Assessment Programs
http://www.dnr.state.mn.us/eco/wetlands/index.html

CWAMMS – Comprehensive Wetland Assessment, Monitoring, and Mapping Strategy
http://files.dnr.state.mn.us/eco/wetlands/wetland_monitoring.pdf

REGIONAL

Ducks Unlimited – GLARO NWI Update
http://www.ducks.org/Conservation/GLARO/3752/GISNWIUpdate.html

Wetlands in the Great Lakes Region
http://www.great-lakes.net/envt/air-land/wetlands.html

NATIONAL

National Wetlands Inventory - NWI
http://www.fws.gov/wetlands/

NWI Maps on Google Earth
http://www.fws.gov/wetlands/Data/GoogleEarth.html

Cowardin Wetland Classification System
http://www.fws.gov/wetlands/_documents/gNSDI/ClassificationWetlandsDeepwaterHabitatsUS.pdf

USACE – Remote Sensing/GIS Center
http://www.crrel.usace.army.mil/rsgisc/

Wetland Mapping and Inventory - USGS
http://water.usgs.gov/nwsum/WSP2425/mapping.html

Wetlands – EPA
http://www.epa.gov/owow/wetlands/

NASA Biomass and Wetlands Maps – North American Boreal Zone
http://www-radar.jpl.nasa.gov/boreal/index.html

INTERNATIONAL

Canadian Wetland Inventory
http://www.ducks.ca/aboutduc/news/archives/2009/pdf/301-cwi.pdf

The Atlas of Canada - Wetlands
http://atlas.nrcan.gc.ca/site/english/learningresources/theme_modules/wetlands/index.html

RAMSAR – Wetlands of International Importance
http://www.ramsar.org/

GLOBWETLAND – European Space Agency RAMSAR project
http://www.globwetland.org/

ACADEMIC

University of Minnesota – Remote Sensing and Geospatial Analysis Laboratory
http://rsl.gis.umn.edu/aboutrsl.html

Michigan Tech Research Institute – Remote Sensing of Wetlands and Invasive Species
http://www.mtri.org/wetlands.html

Saint Mary's University – GeoSpatial Services
http://www.geospatialservices.org/profile.htm

WETMAPP – Wetland Education Through Maps And Aerial Photography
http://www.wetmaap.org/

PROFESSIONAL

American Society for Photogrammetry and Remote Sensing – W. Great Lakes Region
http://www.asprs.org/wgl/

Minnesota Wetland Professionals Association
http://www.mnwetlandprofessionals.org/

Association of State Wetland Managers – Wetland Mapping
http://www.aswm.org/swp/mapping/index.htm

Society of Wetland Scientists
http://www.sws.org/

Ecological and Hydrological Impacts of Emerald Ash Borer

Rob Slesak, Minnesota Forest Resources Council, St. Paul, MN

Since its discovery in 2002, the invasive emerald ash borer (EAB) has decimated ash populations throughout the Great Lakes region. Efforts to identify EAB control methods have largely been unsuccessful, making it possible that native ash species will eventually be extirpated from North America. In Minnesota, there is particular concern that EAB will have large impacts on the ecology and functioning of black ash (*Fraxinus nigra*) wetlands, which cover over one million acres in the state. Black ash serves as a foundation tree species in these wetlands, and it is expected that its loss will have large impacts on ecosystem functions including those related to site hydrology and vegetative community. Although impacts are almost certain, there is much uncertainty as to the form and magnitude of those impacts, and the likelihood for various management actions to mitigate them. A study has been initiated by researchers at the University of Minnesota, the MN forest Resources Council, and the US Forest Service to address this uncertainty with experimental manipulations that mimic EAB infestation and the silvicultural techniques of clear cutting and group selection harvests. These ash mortality treatments will be combined either with or without tree planting to identify potential replacement species for black ash. Baseline monitoring will occur in 2011, and treatments will be installed during winter 2011-12 followed by assessment of the hydrologic and vegetative community response. Study results will be used to assess EAB impacts on northern black ash wetlands, and provide information for development of management recommendations aimed at mitigating the impacts of EAB by maintaining those wetlands in a forested condition.